APPLICATION FOR PATENT

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Title: Seal for Riser Assembly Telescoping Joint

FIELD OF THE INVENTION

The field of the invention relates to telescoping joints used in offshore applications to connect surface equipment to a sub-sea wellhead.

BACKGROUND OF THE INVENTION

When sub-sea wellheads need to be connected to a floating platform or a vessel a telescoping joint is employed to compensate for surface wave action. The telescoping joint typically is an assembly of an outer barrel around an inner barrel with the seal assembly in the annular space between. Pressure can be applied behind such seals to further encourage them into sealing contact with the inner barrel. Various resilient materials that can withstand the service have been used including nitrile rubber. The American Petroleum Institute (API) has established pressure ratings for such seals in its specification 16F, which calls for testing to 200PSI.

However, when higher operating pressures were desired, known seals for telescoping joints were not capable of reliable operation and the present invention involves a variety of designs, which have allowed working pressures of 750PSI with reliable operation. The new configurations and new materials used for these seals are capable of performing reliably at higher pressures without undue wear or significant issues of leakage.

The complexity of known seals is more readily seen by Referring to Fig. **1**, which juxtaposes a known seal design **K** against an embodiment of the present invention.

Referring to Fig. **1**, the known seal assembly **K** comprises an annularly shaped seal **10** made of nitrile rubber having an embedded upper stiffener ring **12** and a lower stiffener ring **14**. A backup ring **16** has perforations **18**. Perforations **18** allow pressurized air from inlet **20** to push the seal **10**, and more particularly sealing face **22** against the inner barrel **24**. Outlet **26** allows release of pressure from chamber **28** using an external control system (not shown) which modulates pressure in chamber **28** to be slightly above the pressure between the housing **30**, which is connected to the outer barrel (not shown) and the inner barrel **24**. As shown in Fig. **1**, housing **30** has a lower body **32** to which are mounted an upper compression ring **34** and a lower compression ring **36**. At the upper end **38** of lower compression ring **36** a seal ring **40** is mounted for contact with seal **10**. Similarly, upper compression ring **34**, which has several components, also comprises a seal ring **42** for contact with seal **10**. Cap screws **44** hold the mating surfaces of the lower compression ring **36** and body **32** together. Tightening nut **48** to stud **46** brings the upper compression ring **34** down on seal **10** to put it into longitudinal compression, for sealing at its ends using seal rings **40** and **42**. Wear bands **50** and **52** respectively protect the upper compression ring **34** and the lower compression ring **36** from wear due to stroking movement of the inner barrel **24**. The housing **30** has a connector **54** for mounting of a second seal, in Fig. **1** the second seal **56** is, in fact, one of the embodiments of the present invention. A second or third or more seals are frequently known to be assembled in to a housing such as **30** so that if a first seal such as **10** has a failure, operation may continue without downtime as pressure is provided behind another seal to energize it into contact with the inner barrel **24**. The use of multiple seals is intended to be a part of the invention, particularly when incorporating the seal assembly **56**, as is the seal assembly

itself and how an individual assembly interacts with the surrounding housing as well as the housing configuration itself. Fig. **1** presents a convenient way to juxtapose the old seal design against one embodiment of the present inventive seal design. Those skilled in the art will appreciate that the known design for the seal **10** is difficult and costly to manufacture. It has operational pressure limits in the order of about 200-500 PSI for continuous reliable operation. It requires careful placement of the end seal rings **40** and **42** and the stiffening effect from the backing ring **16** working in conjunction with the upper stiffening ring **12** and lower stiffening ring **14**. The advantages of the various embodiments of the present invention will be readily appreciated by those skilled in the art from a review of the description of the preferred embodiment, which appears below.

SUMMARY OF THE INVENTION

A new seal system for a marine riser telescoping joint is revealed. The sealing face of the seal has tapered upper and/or lower tapered surfaces. The upper and/or lower ends can have a taper of about 1-15 degrees or alternatively the surrounding housing can have the taper with the seal ends either straight cut or tapered so that the combined tapers are in the stated range. The sealing elements are preferably nitrile or polyurethane and preferably without inserts. The upper and/or lower ends of the seal can have projections or depressions to aid in end sealing and eliminate the need for end seal rings. The new seals can be used individually or in stacks in a single housing or in multiple housings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure **1** is a sectional elevation view of a telescoping joint seal assembly showing an old seal **10** juxtaposed with an embodiment of a new seal **56**;

Figure **2** shows a tandem arrangement of one of the seal designs of the present invention;

Figure **3** is an alternative mounting to Fig. **2**;

Figure **4** illustrates the taper feature in the surrounding housing at the upper and lower ends of the seal;

Figure **5** is a tandem arrangement showing the end protrusions;

Figure **6** is the view of Fig. **5** showing a stack of three seals;

Figure **7** is a tandem arrangement showing a protrusion on one end and a flat opposite end;

Figure **8** is a tandem arrangement showing a protrusion on one end of the seal abutting a flat on the housing and a tapered surface on the housing or the seal on the opposed end;

Figures **9-14** show alternative configurations of the seal in section view.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. **1** is also illustrative of one of the embodiments of the present invention. Seal **56** can be optionally used with a backup ring 58. In Fig. **2** the seal **60** is used without such a backup ring. As better seen in Fig. **2**, the seal **60** has surfaces **62** and **64**, which face the inner barrel **66** (shown schematically and removed in the seal area for clarity) and are disposed above and below surface **68**. Projections **70** and **72** are respectively at the upper and lower ends of the seal **60**. They respectively extend into depressions **74** and **76** in the housing **77**. This arrangement is reversible so that the protrusions are on the housing **77** while the depressions are on the seal **60**. Grooves **78** and **80** are used to retain grease to reduce the wear of surface **68** by movements of the inner barrel **66**. Seal **60** is

energized to seal against inner barrel **66** by applying air pressure at inlet 82, in a known manner. The protrusions **70** and **72** are compressed toward each other by the depressions **74** and **76** to enhance end sealing. This longitudinal compression and the interlocking nature of the end contact between the seal **60** and the housing **77** replaces the more complex system of the prior seal **10**, which used separate seal rings **40** and **42**. The taper angle of surfaces **62** and **64** allows a greater degree of flexing of the seal **60**, particularly when activated by air pressure at inlet **82**. When used in tandem, only one seal is activated into contact with the inner barrel **66** after pressure is applied to its respective inlet **82**. The flexing provided by the taper of about 1-15 degrees on surfaces **62** and **64**, allows surface **68** to make better sealing contact with the inner barrel **66.** The preferred material is a polyurethane of a durometer reading of 70A made from a TDI polyether, with ultimate tensile strength of about 1300 PSI, elongation above 600%, rebound greater than 58% and a compression set of about 25%.

Figs. **9** and **11** illustrate protrusions **84** and **86**, which are respectively U or V shaped. These shapes can be identical at both ends, as shown, or they can be combined so one is at one end and the other is at the opposite end. Other protrusion shapes are contemplated such as rounded, oval, or elliptical to mention a few. The angles at the corners of the protrusions, if present, can be 90 degrees or greater, preferably. Included angles of less than 90 degrees can be used, giving the protrusions **84** and **86** the appearance of having an undercut when viewed in end section. Figs. **10** and **12** illustrate the mirror image end treatment as compared with Figs. **9** and **11**. If depressions **88** and **90** were used, the adjacent housing would, of course, have the mating projections. The same

variability previously described in conjunction with protrusions **84** and **86** are applicable in mirror image to depressions **88** and **90**.

Fig. **2** illustrates a circular rib **92** to separate seals **60** and **94**. A passage **96** can be used to detect leakage of seal **94** before seal **60** is energized into sealing surface by adding pressure at inlet **82**. It should be noted that depressions **74** and **76** are somewhat wider than the projections **70** and **72** that extend into them. This feature allows seal **60** to be easily inserted and centered and promotes flexing under air pressure supplied to inlet **82**, when it is desired to energize surface **68** into contact with the inner barrel **66**. Fig. **3** is similar to Fig. **2** insofar as the seal design with the main difference being the use of a longer housing spacer ring **96** between the two seals **60** and **94**. Note also the use of lubrication ports such as **97** to lubricate seal **94** and associated wear bands such as **99**. Figs. **5** and **6** are similar to Fig. **3** except the seals **98** are shorter and have a single grease groove **100**. Fig. **5** illustrates the use of tandem seals while Fig. **6** uses a stack of three for additional backup capability.

Fig. **7** illustrates another variation involving the optional backup ring **101** used with tandem seals **102** and **104**, where each seal has a flat end (**106** and **108**) and a protrusion (**110** and **112**) at the opposite end. A circular rib **114** separates the two seals **102** and **104** at the respective flat ends **106** and **108**. The protrusions **106** and **108** could alternatively be depressions mating with protrusions on the adjacent housing. Alternatively, protrusions could be used at both ends of each seal **102** and **104**, or depressions. The flat ends could be used instead of protrusions **110** and **112**, although if this is done it is preferred that the adjacent housing have a slope to encourage

compression of the seal end in a manner described below, to encourage the ends to seal more positively.

Another feature of the present invention is the angular end compression of a seal, such as **114** in Fig. **4**, in one of several ways. The housing components **116** and **118** can have sloping surfaces which contact the ends of seal **114** so as to compress it upon installation in a range or about 1-15 degrees, as shown schematically by angle **120**. Instead of slanting the housing surface, which is somewhat difficult to manufacture, the same result can be obtained by flaring out the ends of the seal **114** by making angles **122** and **124** in the range of about 91-105 degrees and the mating housing surface perpendicular to the longitudinal axis of the telescoping joint. Figs. **13** and **14** illustrate seals that can be used in Fig. **4** when the housing mating surfaces are slanted and angles **122** and **124** are at about 90 degrees. Of course, a combination of sloping housing surfaces can be used in contact with sloping ends on the seal **114** if the net result is an angular compression of the ends of seal **114** in the range of about 1-15 degrees. For example the housing surface can be at 95 degrees from the longitudinal axis while angles **122** and **124** can also be 95 degrees to give a net angular compaction of each end of seal **114** of 10 degrees. Other combinations, within or outside of the preferred angular compaction range are also within the scope of the invention.

Just as the backup ring **101** is optional so is the relief **126** shown in Fig. **14** but absent in Fig. **13**. The grease groves can be U or V shaped or both shapes can be used in the same seal. Fig. **8** illustrates the use of the seal of Fig. **14** in a tandem arrangement.

Those skilled in the art will appreciate that the angular compression can serve as an alternate way of end sealing to the protrusion depression technique, previously

described. Alternatively they could also be combined to get the additive effect of both techniques. The end treatments can be identical or they can be different using a mix and match technique with the disclosed ways of end sealing. The angular compression of the seal further promoted the subsequent contact with the inner barrel **66** when a given seal is energized into contact by applied air pressure.

The above description is illustrative of the preferred embodiment and many modifications made be made by those skilled in the art without departing from the invention whose scope is to be determined from the literal and equivalent scope of the claims below: